Guidance on Life-Cycle Cost Analysis Required by Executive Order 13123

January 8, 2003

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Executive Summary

Section 401 of Executive Order 13123 requires that "Agencies shall use life-cycle cost analysis in making decisions about investments in products, services, construction, and other projects to lower the Federal Government's costs and to reduce energy and water consumption…"

The purpose of this guidance is to "clarify how agencies determine the life-cycle cost for investments required by the Order, including how to compare different energy and fuel options and assess the current tools" (Section 502(d)); and "assist agencies in ensuring that all project cost estimates, bids, and agency budget requests for design, construction and renovation of facilities are based on life-cycle costs." (Section 505(a))

Definition of Life-Cycle Costs

Section 707 of Executive Order 13123 defines life-cycle costs as "…the sum of present values of investment costs, capital costs, installation costs, energy costs, operating costs, maintenance costs, and disposal costs over the life-time of the project, product, or measure."

Life-cycle cost analysis (LCCA) is an economic method of project evaluation in which all costs arising from owning, operating, maintaining, and disposing of a project are considered important to the decision. LCCA is particularly suited to the evaluation of design alternatives that satisfy a required performance level, but that may have differing investment, operating, maintenance, or repair costs; and possibly different life spans. LCCA can be applied to any capital investment decision, and is particularly relevant when high initial costs are traded for reduced future cost obligations.

Scope of Guidance

This guidance summarizes the life-cycle cost (LCC) requirements of Executive Order 13123. Decision-makers should be aware that the use of LCCA is required by law and Executive Order and that relevant LCC procedures and tools are well developed and have been supported by the Department of Energy's Federal Energy Management Program (FEMP) and other agencies for over 20 years. This guidance provides a discussion of LCCA that combines generic present-value analysis with the LCCA regulatory criteria (10 CFR 436A) promulgated by FEMP. These criteria apply specifically to energy and water conservation and renewable energy projects in Federal buildings.

Products, Services, and Other Projects Covered by Executive Order 13123

The projects, products, services, construction, and other projects mentioned in Executive Order 13123 that are to be evaluated using LCCA, include but are not limited to the following (all are subject to LCC criteria in 10 CFR 436A):

- Energy and water conservation, and renewable energy projects in Federal buildings, industrial facilities, and laboratories;
- Energy savings performance contracts and utility contracts and other alternative financing contracting mechanisms;
- Bundling of energy efficiency products with renewable energy products and retirement of inefficient equipment on an accelerated basis;
- ENERGY STAR and other energy-efficient products, strategies, and tools; including sustainable building design, model lease provisions, industrial facility efficiency improvements, and off-grid generation.
- Electricity use; and,
- Mobile equipment.

Evaluation of ESPCs and Utility Contracts

The general principles of LCCA also apply to the evaluation of projects considered for alternative financing through an Energy Savings Performance Contract (ESPC) or a Utility Contract (UC). LCCA can be used to compare the costs of the existing equipment over a given time period with the costs over the same time period of an energy conservation measure (ECM) proposed by an energy service company. The costs of performing a feasibility study, setting up and administering the contract, and financing the project through the energy service company can all be included in the LCCA. LCCA allows the analyst to compare the life-cycle costs of financed ECMs with those of agency-funded ECMs, the latter implemented either immediately or in a future year. Assumptions and requirements regarding financing-related input data, study periods, and inflation treatment need to be considered.

Bundling of Energy Efficiency Projects

Section 401 of Executive Order 13123 states that "Where appropriate, agencies shall consider the life-cycle costs of combinations of projects, particularly to encourage bundling of energy efficiency projects with renewable energy projects. Agencies shall also retire inefficient equipment on an accelerated basis where replacement results in lower life-cycle costs."

Individual energy conservation measures should be bundled together to optimize energy, cost, and/or environmental benefits of a project. Renewable energy measures and other measures that save great amounts of energy, improve energy-related infrastructure, reduce air pollution, or reduce greenhouse gas emissions may be bundled with other ECMs as long as the overall project is life-cycle cost effective. All items in the bundle must be complementary, i.e., an integral part of the project, and no single ECM should be significantly cost-ineffective. Furthermore, energy managers should take an integrated systems approach when defining the scope of a building retrofit or other energy-related project. In many cases, a decision about one ECM will directly affect the scope or type of other ECMs.

Life-Cycle Cost for Energy-Using Products

When purchasing energy-using products, agencies should perform an LCCA to assure that they are making a cost-effective selection. Pursuant to the FAR Section 23.704, agencies can purchase cost-effective energy-efficient products even if the first cost is higher than a less efficient product.

Basis for LCCA Guidance

This guidance does not supersede agency practices that are prescribed by or pursuant to law, Executive Order, or other relevant documents. It is meant to assist agencies in conducting life-cycle cost analyses of investments in products, services, construction, and other projects. The methodology is explained in the context of energy and water conservation and renewable energy projects in federal buildings according to 10 CFR 436A, but it is applicable to any products, services, and other projects where future operational savings are traded off against higher initial investment costs.

The LCC methodology and procedures of 10 CFR 436A (as explained in NIST Handbook 135) are consistent with American Society for Testing and Materials (ASTM) Standards on Building Economics, in particular ASTM Standard Practices E917, E964, E1057, E1074, E1121, and E1185. The supporting NIST LCC computer software (BLCC) can generally be used to analyze any type of project whose costs can be categorized as:

- initial investment costs,
- operation and maintenance costs,
- energy costs and water costs,
- capital replacement costs,
- residual values, and
- financing costs.

Additional Reference Materials

The FEMP LCC rules in 10 CFR 436A are explained in NIST Handbook 135 *Life-Cycle Costing Manual for the Federal Energy Management Program* and its annual supplement *Energy Indices and Discount Factors for Life-Cycle Cost Analysis*.

Appendix A of this guidance refers the reader to additional Government documents that provide guidance on meeting the LCCA requirements of Executive Order 13123:

- *Facilities Standards for the Public Buildings Service*. This GSA document provides general guidance on LCCA for buildings and building systems.
- *Whole Building Design Guide* provides guidance on sustainable building design.
- *Criteria/Standards for Economic Analysis/Life-Cycle Costing for MILCON Design*. This DOD Tri-Services Memorandum of Agreement provides guidance on LCCA for military construction design.

Authority

This LCC guidance is issued under the authority of Executive Order 13123, June 3, 1999. The use of life-cycle costing to evaluate energy and water conservation, and renewable energy projects in the Federal Government arises from the requirements of the National Energy Conservation Policy Act (NECPA) of 1978 (PL 95-619), as amended; the Energy Policy Act of 1992 (PL 102-486); and subsequent legislation and Executive Orders. The LCC rules and regulations, codified in 10 CFR 436, Subpart A, *Life-Cycle Cost Methodology and Procedures*, were published by DOE in 45 FR 5820 on January 23, 1980, and amended in 1990 and 1996 (FR, Vol. 55, No. 224, November 20, 1990; FR, Vol. 61, No. 123, June 25, 1996).

1. General Principles of Life-Cycle-Cost Method

(a) Definition

Life-cycle cost analysis (LCCA) is a method for evaluating all relevant costs over time of a project, product, or measure. The LCC method takes into account first costs, including capital investment costs, purchase, and installation costs; future costs, including energy costs, operating costs, maintenance costs, capital replacement costs, financing costs; and any resale, salvage, or disposal cost, over the life-time of the project, product, or measure.

(b) Time adjustments

Adjustments to place all dollar values expended or received over time on a comparable basis are necessary for the valid assessment of a project's life-cycle costs and benefits. Time adjustment is necessary because a dollar today does not have equivalent value to a dollar in the future. There are two reasons for this disparity in value. First, money has real earning potential over time among alternative investment opportunities, and future revenues or savings always carry some risk. Thus an investor will require a premium or extra return for postponing to the future the spending of that dollar. Second, in an inflationary economy, purchasing power of money erodes over time. Thus a person would demand more than a dollar at some future time to obtain equivalent purchasing power to a dollar held today.

The process of converting streams of benefits and costs over time in the future back to an equivalent "present value" is called discounting. A discount rate is used in special formulas to convert future values. When future values are expressed in current (nominal) dollars, where inflation is included in the future values, a market (nominal) discount rate is used. It takes into account both inflation and the earning potential of money over time. When future values are expressed in real (constant dollar) terms, where general price inflation has been stripped out, a real discount rate is used. It takes into account only the earning potential of money over time. Both approaches yield identical results as long as you use real discount rates in discounting constant-dollar future amounts and market discount rates in discounting current-dollar future amounts.

Choices among energy-savings projects can be made either by estimating for each alternative project a stream of life-cycle costs and savings relative to a "base case," and computing the net present value (NPV) of that stream (looking for the maximum NPV), or by calculating the present value of each project's life-cycle cost, and choosing the alternative (including "do nothing") that yields the minimum present-value life-cycle cost (PVLCC). Both methods are embodied in the training that FEMP and NIST provide and in their software, "BLCC 4.0," and when performed correctly, both methods will yield the same results. If you have already computed cost and savings streams for the projects, then you could use a spreadsheet program to compute the NPV of those streams instead of using BLCC.

(c) Life-Cycle Cost formula

To find the total LCC of a project, sum the present values of each kind of cost and subtract the present values of any positive cash flows such as a resale value. Thus, where all dollar amounts are converted to present value by discounting, the following formula applies:

Life-cycle cost = first cost + maintenance and repair + energy + water
+ replacement - salvage value.

(d) Applications of LCCA

Projects may be compared by computing the LCC for each project, using the formula above and seeing which is lower. The alternative with the lowest LCC is the one chosen for implementation, other things being equal.

The LCC method can be applied to many different kinds of decisions when the focus is on determining the least-cost alternative for achieving a given level of performance. For example, it can be used to compare the long-run costs of two building designs; to determine the expected savings of retrofitting a building for energy or water conservation, whether financed or agency-funded; to determine the least expensive way of reaching a targeted energy use for a building; or to determine the optimal size of a building system.

In addition to the LCC formula shown above, there are other methods for combining present values to measure a project's economic performance over time, such as Net Savings, Savings-to-Investment Ratio, Adjusted Internal Rate of Return or Discounted Payback.

(e) Note on Discounted Payback (DPB) and Simple Payback (SPB)

Discounted Payback (DPB) and Simple Payback (SPB) measure the time required to recover initial investment costs. The payback period of a project is expressed as the number of years just sufficient for initial investment costs to be offset by cumulative annual savings.

DPB is the preferred method of computing the payback period for a project because it requires that cash flows occurring each year be discounted to present value to adjust for the effect of inflation and the opportunity cost of money. The SPB does not use discounted cash flows and therefore ignores the time value of money, making it a less accurate measure than the DPB.

In practice, the DPB or SPB is used to measure the time period required for accumulated savings to offset *initial* investment costs. Any costs or savings incurred during the remainder of the project life-cycle are ignored. The DPB and the SPB are therefore not appropriate measures of life-cycle cost effectiveness and should be used only as screening tools for qualifying projects for further economic evaluation.

(f) Uncertainty assessment

Estimates of costs are typically uncertain because of imprecision in the underlying data and modeling assumptions. If there is substantial uncertainty it is useful to analyze and report its effects. There are numerous methods for analyzing uncertainty and risk. The technique to be used depends on the degree of uncertainty and the size of the project. Deterministic analysis, such as *sensitivity analysis* and *breakeven analysis* can be performed within the LCCA method without requiring additional computational aids. *Probability distributions* of economic measures may require more or less complex simulation techniques but may be warranted by the magnitude of some projects. If additional analysis casts considerable doubt on the LCCA, an agency should consider obtaining more reliable data or eliminating the alternative.

(g) Considering emissions reductions from energy-conserving alternative

The BLCC computer program, which supports LCCA for energy and water conservation in federal buildings, has the capability of estimating annual and life-cycle CO_2, SO_2, and No_x emissions coincident with the energy use of the building or building system being evaluated. Emissions are calculated for electricity, fuel oil, natural gas, LPG, and coal; they are *not* calculated for central steam, chilled water, and “other” energy types that can be included in the BLCC input file. The economic cost of these emissions is not estimated, but quantitative estimates of emissions reductions attributable to an energy-saving alternative are included in the LCC report of the program. The emissions factors used in the BLCC analysis are based on national average data. They can be modified to reflect local emissions data for electricity and fossil fuels.

2. Federal LCC Criteria

The most critical assumptions of the LCC rules in 10 CFR 426A and OMB Circular A-94 concern the

- Discount rate
- DOE energy price escalation rates
- Use of constant or current dollars
- Study period
- Presumption of cost-effectiveness

(a) Discount rate

DOE/FEMP discount rates for energy and water conservation projects: The Department of Energy determines each year the discount rate to be used in the LCCA of energy conservation, water conservation, and renewable energy projects in federal facilities. According to 10 CFR 436A,

> *“Subject to a ceiling of 10 percent and a floor of three percent the real discount rate shall be a 12 month average of the composite yields of all outstanding U.S.*

Treasury bonds neither due nor callable in less than ten years, as most recently reported by the Federal Reserve Board, adjusted to exclude estimated increases in the general level of prices consistent with projections of inflation in the most recent Economic Report of the President's Council of Economic Advisors."

The *nominal* discount rate is derived identically but is unadjusted for increases in the general level of prices.

The real discount rate and corresponding discount factors are updated annually on April 1 and published in NISTIR 85-3273, *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis*, the Annual Supplement to NIST Handbook 135.

OMB discount rates for non-energy and non-water conservation projects: OMB has specified two basic types of discount rates: (1) a discount rate for cost-effectiveness, lease-purchase, and related analyses; and (2) a discount rate for public investment and regulatory analyses. Only discount rates for the first type of analyses are relevant to this Guidance, since its primary purpose is to support cost-effectiveness studies related to the design and operation of federal facilities.

OMB discount rates for cost-effectiveness and lease-purchase studies are based on interest rates on Treasury Notes and Bonds with maturities ranging from 3 to 30 years. Five maturities (3-, 5-, 7-, 10-, and 30-year) have been specifically identified by OMB, and their *real* interest rates are used as the discount rates for studies subject to OMB Circular A-94. OMB suggests that the actual discount rate for an economic analysis be interpolated from these maturities and rates, based on the length of the study period used in the analysis.

The *nominal* discount rate is derived identically but is unadjusted for increases in the general level of prices. The nominal discount rate is used for current-dollar analyses, whereas the real discount rate is used for constant-dollar analyses (see definition of constant-dollar and current-dollar analysis in subsection (c) below).

(b) DOE energy price escalation rates

The discount rates and corresponding discount factors are assumed to change at rates different from the rate of general price inflation. The DOE Energy Information Administration annually projects real energy price escalation rates for the next 35 years, by census region, rate type, and fuel type. These real energy price escalation rates and the real DOE discount rate are used to calculate the modified present value (UPV*) factors for use in FEMP LCC analyses. The UPV* factors are updated and published annually on April 1 as a set of tables in *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis,* NISTIR 85-3273, the Annual Supplement to Handbook 135. They are also incorporated into the BLCC computer programs.

(c) Use of constant dollars

It is recommended that in general all future dollar amounts be estimated in *constant* dollars, with the purchasing power of the dollar fixed as of the base date. This convention eliminates the need to estimate the rate of general price inflation over the study period. If future amounts are estimated in constant dollars, only the annual costs as of the base-date are needed as data inputs into the LCCA. The constant-dollar amounts are then discounted from their date of occurrence to the base date using a *real* discount rate (i.e., a rate that also excludes general price inflation).

The FEMP rule allows the option of estimating LCC in *current* dollars, that is, in dollars that include the rate of general price inflation. The LCCA needs to be performed in current dollars when, for example, tax calculations, budget allocations, or fixed contract payments have to be included in the analysis, that is, whenever there are amounts that have to be evaluated or paid or budgeted as amounts that include the inflation rate. It is also more convenient to use current-dollar analysis when the analysis includes amounts that change at the rate of inflation as well as amounts that are fixed, such as an annual or monthly contract payment. Thus, an evaluation of ESPC or Utility Contracts would require current-dollar analysis including the rate of inflation in the discount rate, escalation rates, and loan interest rate.

(d) Study period

The maximum study period for federal energy and water conservation and renewable energy projects according to 10 CFR 436A is 25 years from the date of occupancy of a building or the date of operation of a system. Any lead-time for planning, design, construction, or installation may be added to the 25-year maximum study period.

OMB Circular A-94 does not limit the length of the study period for LCCA analyses of buildings.

(e) Presumption of cost effectiveness

1. A project is *presumed cost-effective* if it saves energy or water and if the costs of implementing the energy or water conservation measure are insignificant, and
2. A project is *presumed not cost-effective* if the building is:

   - occupied under a one-year lease without renewal option or with a renewal option that is not likely to be exercised;
   - occupied under a lease that includes the cost of utilities in the rent, with no pass-through to the government of energy or water savings; or
   - scheduled for demolition or retirement within one year.

3. Evaluation of ESPCs and Utility Contracts

The general principles of LCCA, as described in this document, also apply to the evaluation of projects that are considered for alternative financing through an Energy Savings Performance Contract (ESPC) or a Utility Contract (UC). LCCA can be used to compare the costs of the existing equipment over a given time period with the costs over the same time period of a project proposed by an Energy Service Company (ESCO) or utility. The costs of performing a feasibility study, setting up and administering the contract, and financing the project through the ESCO or utility can all be included in the LCCA. The BLCC program, in addition to the detailed LCC report showing lowest LCC, also prints out a listing of undiscounted year-to-year cash flows, which allow the analyst to determine whether the total cost savings or energy-related savings of the project are sufficient to cover the proposed contract payments.

LCCA also allows the analyst to compare the life-cycle costs of financed Energy Conservation Measures (ECMs) with those of agency-funded ECMs, the latter implemented either immediately or in a future year.

When evaluating ESPCs or UCs, using the BLCC program, some additional input data and assumptions are needed.

(a) Financing-related input data

- Investment amounts to be financed
- Contract payments
- Contract term
- Borrowing rate

(b) Assumptions

- ***Base date and service date***: For the purpose of performing an LCCA, the base date is the point in time to which all project-related costs are discounted. The base date is the first day of the study period for the project, usually considered synonymous with the date at which the study is performed. The service date is the date on which the building is occupied or a system is taken into service; operating and maintenance costs (including energy- and water-related costs) are generally incurred after this date, not before.

  In the case of a retrofit to an existing building, the base date and service date coincide, because the existing equipment continues to consume energy and require maintenance while the energy conservation measures are installed. Energy and non-fuel costs have to be adjusted to account for the changes during the installation period. This case usually applies to projects proposed under ESPCs or UCs.

  In the case of equipment for new buildings, the service date may be later than the base date if there is a planning/construction period. The study period then consists of the planning/construction period and the service period. Operation, maintenance and energy costs in this case are calculated beginning with the service date, the date at which the building is occupied and the equipment is taken into service. Annual costs are evaluated over the service period and discounted to the base date, i.e., the beginning of the study period. In the case of equipment for new buildings, the same service date has to be used for all project alternatives and the base case. A new office building, for example, that can be occupied sooner has additional benefits and costs to the user that would invalidate the direct comparison of LCCs.

- ***Current-dollar analysis***: The rate of inflation has to be included when ESPCs or UCs are evaluated, (1) because the contract payments proposed by the ESCO are determined using a market interest rate, which includes inflation, and (2) during the contract term, fixed contract payments are compared from year to year with undiscounted, current-dollar savings. For these reasons, the analysis should be performed in current dollars, and the discount rate and all escalation rates need to include inflation. The NIST Building Life-Cycle Cost (BLCC) Program, BLCC5, contains a module, "Federal Analysis, Financed Projects," which is dedicated to ESPC and UESC analyses and uses current-dollar analysis as a default.

- *Cost of feasibility studies/"Sunk Costs":* If, in the case of ESPCs or UCs, the costs of feasibility studies were incurred or committed before the base date of your LCCA, they are "sunk costs" and can be omitted from the LCC computation. By definition, sunk costs cannot be changed by the selection of any project alternative and thus cannot affect its LCC or the LCC of competing alternatives.

4. Bundling of Energy Efficiency Projects

Bundling of energy efficiency projects is allowed according to ESPC and UC guidelines. In addition, Executive Order 13123 encourages bundling as follows:

> *"…Where appropriate, agencies shall consider the life cycle costs of combinations of projects, particularly to encourage bundling of energy efficiency projects with renewable energy projects. Agencies shall also retire inefficient equipment on an accelerated basis where replacement results in lower life-cycle costs…"* (Section 401, Executive Order 13123)

Energy managers should take an integrated systems approach when defining the scope of a building retrofit or other energy-related project. In many cases, a decision about one ECM will directly affect the scope or type of other ECMs. Individual energy conservation measures should be bundled together to optimize energy, cost, and/or environmental benefits of a project. The Executive Order cites two examples -- renewable energy projects and retirement of obsolete equipment -- when less cost-effective ECMs may be combined in a project with ECMs with larger net savings and implemented as a single, bundled ESPC or UC project. Similarly, load management efforts and other measures that save great amounts of energy, reduce energy costs, improve energy-related infrastructure, reduce air pollution, or reduce greenhouse gas emissions may also be bundled with other ECMs as long as the overall project is life-cycle cost effective. Individual energy conservation measures must be reasonably related to the overall project as a whole, i.e. an integral part of the project, and no single ECM should be significantly cost-ineffective. The bundled project must be life-cycle cost effective.

5. Life-Cycle Cost for Energy-Using Products

When purchasing energy-using products agencies should perform an LCCA to assure that they are making a cost-effective selection. Pursuant to the FAR Section 23.704, agencies can purchase cost-effective energy-efficient products even if the first cost is higher than a less efficient product.

To assist agencies in calculating the LCC of energy-efficient products, FEMP has developed cost-effectiveness examples for 34 product types, ranging from household dishwashers to water-cooled electric chillers. The cost-effectiveness examples are presented as part of FEMP's popular one-sheet *Product Energy Efficiency Recommendations* (an example is included as Appendix C). Each one uses the NIST-prescribed LCC methodology for discounting future costs and savings, which incorporates future energy price trends (as predicted by DOE's Energy Information Administration). FEMP uses standard industry assumptions for key variables such as annual hours of operation, as well as federal average energy prices, and then calculates the energy cost savings that would accrue from purchasing a "recommended" and "best available" model, compared with one that just meets a legal minimum efficiency (as prescribed by the National Appliance Energy Conservation Act for most residential appliances and equipment, or, for many types of commercial equipment, ASHRAE standard 90.1). For example, the lifetime energy cost savings (over an estimated 19-year life) for a FEMP-recommended 21 cubic foot refrigerator compared to one that just meets the NAECA standard is $100(in present value). For the most efficient alternative on the market, the energy savings would be $180. The recommended levels are those prescribed by FEMP for meeting Executive Order 13123's call for agencies to purchase, where cost-effective, Energy Star labeled products, or products in the top 25% of energy efficiency of their type and size.

This "lifetime energy cost savings" figure gives users a dollar figure to compare with the product's price premium; if the additional purchase cost of the more efficient item is less than the lifetime savings from energy, the efficient product is economically justified. Additionally, the *Recommendations* provide the proper linear adjustments so users can adjust the examples for their own utility rates, hours of operation, or product capacities (FEMP tries to choose common or average capacities, such as 10,000 Btu/hour for room air conditioners, or 500 tons for centrifugal chillers).

FEMP is also developing interactive web-based "cost calculators" so that agency users can easily tailor their own product cost-effectiveness estimates. FEMP provides reasonable default values for cases where, for instance, the user may not have an estimate for the operating hours of his or her facility's air conditioner. However, almost all the relevant variables are modifiable. The calculators are available for several products covered in the *Recommendation* series, by first going to the "Buying Energy Efficient Products" web site, at www.eren.doe.gov/femp/procurement, and then proceeding to the "Cost-Effectiveness Example" of one of the products. Presently, calculators are available for refrigerators, commercial unitary air conditioners, commercial heat pumps, commercial boilers, fluorescent tube luminaires, and several plumbing products. More will be added soon.

6. Assessment of Building Life-Cycle Cost Computer Programs

(a) NIST Building Life-Cycle Cost Computer Program BLCC5, developed by the National Institute of Standards and Technology, provides comprehensive economic analysis of proposed capital investments expected to reduce long-term operating costs of buildings or building systems. The multi-platform program calculates lowest life-cycle costs, net savings, savings-to-investment ratio, internal rate of return and payback for any alternative relative to a base case. It complies with American Society for Testing and Materials (ASTM) standards related to building economics and is consistent *with NIST Handbook 135, Life-Cycle Costing Manual for the Federal Energy Management Program*.

The program provides economic analysis for the following project environments:

- **FEMP Analysis, Energy Project:** Energy and water conservation and renewable energy projects falling under Federal Energy Management Program (FEMP) guidelines (10CFR436), agency-funded.
- **Federal Analysis, Financed Project:** Federal projects financed through Energy Savings Performance Contracts (ESPC) or Utility Energy Services Contracts (UESC).
- **MILCON Analysis, Energy Project:** Energy and water conservation and renewable energy projects in military construction, agency-funded.
- **MILCON Analysis, ECIP Project:** Energy and water conservation projects under the Department of Defense Energy Conservation Investment Program (ECIP).

(b) BLCC-associated programs (DOS-based)

BCC4: As the predecessor of BLCC5 this program also provides analyses of non-energy projects based on Office of Management and Budget Circular A-94 and of private-sector projects requiring tax analysis. These modules will be transferred to BLCC5 in the future.

EMISS: *A Program for Estimating Local Air Pollution Emission Factors Related to Energy Use in Buildings,* NISTIR 5704, National Institute of Standards and Technology. EMISS is a stand-alone program that generates a file of local air-pollution emission coefficients (CO2, NOx , and SOx) for use with the BLCC program. Emission factors for electricity can be generated by state or geographical region from the EMISS database. Emission factors for fossil fuels used at the site can be generated from estimates of heating value, sulfur content, and end use. BLCC uses this file of emission factors to estimate reductions in emissions associated with energy conservation projects on both an annual and life-cycle basis.

DISCOUNT: *A Program for Discounting Computations in Life-Cycle Cost Analyses,* NISTIR 4513, National Institute of Standards and Technology. The DISCOUNT program computes discount factors and related present values, future values, and periodic payment values of cash flows occurring at specific points. DISCOUNT is especially useful for solving LCC problems that do not require the comprehensive summation and reporting capabilities provided by the BLCC program. DISCOUNT is updated each year on April 1 to incorporate the most recent DOE/EIA energy price escalation rates.

ERATES: *Program for Computing Time-of-Use, Block, and Demand Charges for Electricity Usage,* NISTIR 5186, National Institute of Standards and Technology. ERATES is a computer program for calculating monthly and annual electricity costs under a variety of electric utility rate schedules. Both kWh usage and kW demand can be included in these costs. Most typically these calculations will be used to support engineering-economics studies that assess the cost effectiveness of ECMs or measures to shift electricity use from on-peak to off-peak time periods.

(c) Other LCCA computer programs
Agencies are free to use other LCCA computer programs as long as they are consistent with the life-cycle cost procedures and methodology of 10 CFR 436A and/or OMB Circular A-94.

7. Other LCC Resources

(a) NIST Handbook 135: *Life-Cycle Costing Manual for the Federal Energy Management Program, 1995 edition,* National Institute of Standards and Technology. *Handbook 135* is a guide to understanding the LCC methodology and criteria established by the Federal Energy Management Program (FEMP) in 10 CFR 436A for the economic evaluation of energy and water conservation projects and renewable energy projects in all federal buildings. The purpose of *Handbook 135* is to facilitate the implementation of the FEMP rules by explaining the LCC method, defining the measures of economic performance used, describing the assumptions and procedures to follow in performing evaluations, giving examples, and noting NIST computer software available for computation and reporting purposes.

(b) Annual Supplement to NIST Handbook (ASHB) 135: *Energy Indices and Discount Factors for Life-Cycle Cost Analysis,* NISTIR 85-3273-X**:** The *ASHB 135*,published by NIST and updated annually on April 1, provides energy price indices and discount factor multipliers needed to estimate the present value of energy and other future costs. The data are based on energy price projections developed by the DOE Energy Information Administration. Users of *Handbook 135* will need the most recent version of this report to perform LCC analyses for federal projects. The discount factors listed in the report are incorporated into the BLCC and associated computer programs.

(c) FEMP/NIST LCC Workshops

1. ***Basic LCC Workshop***: The two-day workshop, presented annually by NIST staff in various locations throughout the U.S., provides a standardized framework for evaluating and comparing the economic performance of energy and water conservation, and renewable energy projects in building. It includes class-room instruction, exercises, and computer use of LCC support software.
2. ***Project-Oriented LCC Workshop***: The two-day workshop focuses on practical LCC solutions for energy and water conservation, and renewable energy projects. The workshop is complementary to the Basic LCC workshop taught by NIST and FEMP-Qualified Instructors. Students attending this workshop should have an elementary understanding of the principles of discounted cash flows and LCC analysis.
3. ***DOE/FEMP LCC Telecourse***: The two-hour DOE/FEMP telecourse uses state-of-the-art distance learning technology to demonstrate how to meet federal requirements for life-cycle cost analysis of energy and water conservation, and renewable energy projects. It is an introduction to LCC analysis and is broadcast annually.
4. ***Workshop Registration***: To register for the Basic LCC Workshop or Project-Oriented Workshop contact Cecilia Mendoza, Ph. 509-375-2518, Fax 509-372-4990, cecilia.mendoza@pnl.gov, or register on-line at http://www.pnl.gov/femp. To receive more information on the LCC Telecourse, contact Heather Schoonmaker (423) 576-9135/9137.

Note: Locally sponsored sessions of the Basic FEMP LCC Workshop are also available from FEMP-Qualified Instructors. For further information call the FEMP Help Desk at 1-800-DOE-EREC.

(d) NIST training videos

An introduction to the FEMP LCC method is provided in the following three video training films. They are available through the Office of Applied Economics at NIST by calling 301-975-6132.

1. "An Introduction to Life-Cycle Cost Analysis"
2. "Choosing Economic Evaluation Methods"
3. "Uncertainty and Risk"

(e) Web sites and other contacts

The following are web sites and telephone contacts that offer further LCC-related information:

1. FEMP web site (for downloading BLCC5 and associated programs, ASHB 135, and Software User Guides): http://www.eren.doe.gov/femp - Technical Assistance.

2. FEMP Help Desk (for obtaining hard copies of Handbook 135, ASHB 135, BLCC5 CDs): 1-800-DOE-EREC (1-800-363-3732).
3. NIST Office of Applied Economics (for support on methodology and BLCC4): 301-975-6132: http://www.bfrl.nist.gov/oae/oae.html**.**
4. 10 CFR 436A, *FEMP Life-Cycle Cost Methodology and Procedures,* http://www.access,gpo.gov/nara/cfr/waisidx_00/10cfr436_00.html
5. Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, http://www.whitehouse.gov/WH/EOP/OMB
6. DoD (for obtaining the Tri-Services Memorandum of Agreement *"Criteria/Standards for Economic Analysis/Life-Cycle Costing for MILCON Design"*)
7. "*Whole Building Design Guide",* http://www.wbdg.org. This web site provides guidance on sustainable building design, including guidance on life-cycle cost analysis.

APPENDIX A

Additional Government Documents Providing LCCA Guidance

(a) Office of Management and Budget
For projects that are not primarily concerned with energy or water conservation, Office of Management and Budget (OMB) Circular A-94, *"Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs,"* provides the necessary guidance. The underlying methodologies for the FEMP and OMB rules are identical, except that OMB has different discount rates and does not limit the length of the study period to 25 years.

(b) Department of Defense
A Tri-Services Memorandum of Agreement (MOA) *"Criteria/Standards for Economic Analysis/Life-Cycle Costing for MILCON Design,"* which is updated periodically, provides guidance on LCCA for military construction design. The LCCA rules in this MOA are consistent with 10 CFR 436A and OMB Circular A-94. However, at present the MOA recommends (but does not require) the use of mid-year discounting for all annually recurring costs. It also recommends the lumping together of all initial investment costs at the midpoint of construction for projects that have a beneficial occupancy/service date later than the date of study.

(c) General Services Administration
The General Services Administration (GSA) provides general guidance on LCCA for buildings and building systems in their documents "*Facilities Standards for the Public Buildings Service"* (PBS-PQ100.1). The document refers the reader to 10 CFR 436A for further information and instructions on LCCA.

APPENDIX B

Example of LCC Analysis

Feasibility of Financing Solar Water Heating Systems for a U.S. Coast Guard Base

(a) Project Description

The U.S. Coast Guard (USCG) in Honolulu seeks to evaluate the feasibility of utility financing to replace existing electric resistance water heating systems with solar water heating systems in 278 residences. For the existing system USCG replaces heater tanks at the rate of 27.8 tanks per year (assuming a 10-year useful life) with the first set of tank replacements being completed one year from the base date. As an alternative they could replace the existing systems with an energy-efficient solar system that would be installed and financed through a contract with the local utility and would be ready for operation in one year. USCG would make a down payment of 23 percent of the total initial capital investment of $1,010,000 at the base date and finance the remaining 77 percent over a contract term of 10 years. USCG performs a life-cycle cost analysis to determine if the utility proposal is cost effective.

Location:	Honolulu, HI
Base date:	April 2002
Service date:	April 2003
Length of study period:	21 years
Government discount rate:	5.6 percent (including inflation)
Discounting convention:	Amounts discounted from end of each year to base date
Inflation rate:	2.3 percent (use current-dollar analysis)
Electricity price:	$0.05/kWh, industrial rate

Base Case: Maintain and Repair Existing System

Annual electricity cost: $142,857 (= 2,857,140 kWh at $0.05)

Initial capital investment: None

Capital replacement costs:
Years 5, 10, and 15: $23,760 for anode replacement

Annually recurring OM&R costs: $31,069 for tank flushing and tank replacements

Alternative: Replace Existing System with Solar Water Heating System financed through a Utility Energy Services Contract

Contract-related data:	
Amount financed:	$777,700 =(77% of $1,010,000, at 8.5% interest)
Annual contract payment:	$118,500
Contract term:	10 years
Implementation period:	1 year
Oversight costs:	$3,875 to be paid 1 year from base date
Administrative costs:	$1,000 per year during contract term
Annual energy costs:	Electricity after implementation: $542,000 kWh
Component costs:	
Initial cost paid by agency:	$232,000 (=23% of $1,010,000 as down payment)
Capital Replacement costs:	
Years 6, 11, 16:	$23,760 for anode replacements
Year 11:	$224,920 for tank replacements
Year 16:	$26,582 for valve replacements
Annually recurring OM&R costs:	$10,600 for routine maintenance
Non-annually recurring OM&R costs:	
Years 11 and 16:	$30,000 for repairing controls and insulation

(b)Analysis Results

The LCC analysis shows that financing a solar water system is a cost-effective alternative to keeping the existing system. The *Summary LCC* and *Comparative Analysis* reports below show that the solar water system generates present-value Net Savings of $361,034 over the study period.

The analysis was performed using BLCC5.1-02 for Federal Analysis, Financed Projects. For analysis results, see reports below. Only the *Summary LCC* report and the *Comparative Analysis* report are reproduced here. BLCC5 also provides *Input Data Listing, Detailed LCC, Cash Flow, and Lowest LCC* reports.

APPENDIX B
Example of LCC Analysis: BLCC5 Analysis Reports

NIST BLCC 5.1-02: Summary LCC

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\USCG Water.xml
Date of Study:	Thu Dec 12 11:50:38 EST 2002
Analysis Type:	Federal Analysis, Financed Project
Project Name:	
Project Location:	Hawaii
Analyst:	FMP
Comment:	Finance solar water heating system to replace electric resistance system
Base Date:	April 1, 2002
Study Period:	21 years 0 months (April 1, 2002 through March 31, 2023)
Discount Rate:	5.6%
Discounting Convention:	End-of-Year

Discount and Escalation Rates are NOMINAL (inclusive of general inflation)

Alternative: Existing Electric Resistance System - Base Case

LCC Summary

	Present Value	Annual Value
Initial Cost Paid By Agency	$0	$0
Annually Recurring Contract Costs	$0	$0
Non-Annually Recurring Contract Costs	$0	$0
Energy Consumption Costs	$1,797,056	$147,338
Energy Demand Costs	$0	$0
Energy Utility Rebates	$0	$0
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Annually Recurring OM&R Costs	$469,868	$38,524
Non-Annually Recurring OM&R Costs	$0	$0
Replacement Costs	$53,180	$4,360
Less Remaining Value	$0	$0
	------------	------------
Total Life-Cycle Cost	$2,320,104	$190,222

Alternative: Utility-Financed Solar System

LCC Summary

	Present Value	Annual Value
Initial Cost Paid By Agency	$232,000	$19,021
Annually Recurring Contract Costs	$851,359	$69,802
Non-Annually Recurring Contract Costs	$3,755	$308
Energy Consumption Costs	$444,662	$36,457
Energy Demand Costs	$0	$0
Energy Utility Rebates	$0	$0
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Annually Recurring OM&R Costs	$180,144	$14,770
Non-Annually Recurring OM&R Costs	$21,215	$1,739
Replacement Costs	$225,935	$18,524
Less Remaining Value	$0	$0
	------------	------------
Total Life-Cycle Cost	$1,959,070	$160,621

NIST BLCC 5.1-02: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

Base Case: Existing Electric Resistance System - Base Case
Alternative: Utility-Financed Solar System

General Information

File Name:	C:\Program Files\BLCC5\projects\USCG Water.xml
Date of Study:	Thu Dec 12 11:50:59 EST 2002
Project Name:	
Project Location:	Hawaii
Analysis Type:	Federal Analysis, Financed Project
Analyst:	FMP
Comment	Finance solar water heating system to replace electric resistance system
Base Date:	April 1, 2002
Study Period:	21 years 0 months(April 1, 2002 through March 31, 2023)
Discount Rate:	5.6%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs
PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs Paid By Agency:			
Capital Requirements as of Base Date	$0	$232,000	-$232,000
Future Costs:			
Recurring and Non-Recurring Contract Costs	$0	$855,114	-$855,114
Energy Consumption Costs	$1,797,056	$444,662	$1,352,394
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Recurring and Non-Recurring OM&R Costs	$469,868	$201,359	$268,509
Capital Replacements	$53,180	$225,935	-$172,755
Residual Value at End of Study Period	$0	$0	$0
	------------	------------	------------
Subtotal (for Future Cost Items)	$2,320,104	$1,727,070	$593,034
	------------	------------	------------
Total PV Life-Cycle Cost	$2,320,104	$1,959,070	$361,034

Net Savings from Alternative Compared with Base Case

PV of Operational Savings	$1,620,903
- PV of Differential Costs	$1,259,870

Net Savings	$361,034

NOTE: Meaningful SIR, AIRR and Payback can not be computed for Financed Projects.

Comparison of Contract Payments and Savings from Alternative (undiscounted)

Year Beginning	Savings in Contract Costs	Savings in Energy Costs	Savings in Total Operational Costs	Savings in Total Costs
Apr 2002	$0	$0	$0	-$232,000
Apr 2003	-$123,511	$107,079	$128,499	$4,989
Apr 2004	-$119,571	$105,349	$127,262	$7,691
Apr 2005	-$119,595	$105,824	$128,240	$8,645
Apr 2006	-$119,620	$107,838	$130,770	$11,150
Apr 2007	-$119,646	$110,830	$134,291	$41,265
Apr 2008	-$119,672	$113,897	$137,897	-$9,010
Apr 2009	-$119,699	$116,604	$141,156	$21,456
Apr 2010	-$119,727	$119,375	$144,491	$24,764
Apr 2011	-$119,755	$118,698	$144,392	$24,637
Apr 2012	-$119,784	$120,377	$146,662	$57,960
Apr 2013	$0	$122,657	$111,020	-$208,340
Apr 2014	$0	$125,475	$152,982	$152,982
Apr 2015	$0	$128,671	$156,812	$156,812
Apr 2016	$0	$131,836	$160,624	$160,624
Apr 2017	$0	$134,655	$164,105	$197,524
Apr 2018	$0	$137,750	$167,876	$95,443
Apr 2019	$0	$140,702	$171,523	$171,523
Apr 2020	$0	$143,369	$174,898	$174,898
Apr 2021	$0	$146,082	$178,336	$178,336
Apr 2022	$0	$148,837	$181,830	$181,830

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	2,857,140.0 kWh	652,187.3 kWh	2,204,952.7 kWh	46,296,461.5 kWh

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	9,749.0 MBtu	2,225.4 MBtu	7,523.6 MBtu	157,970.0 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO_2	2,230,273.23 kg	509,139.92 kg	1,721,133.31 kg	36,137,909.27 kg
SO_2	3,918.14 kg	913.42 kg	3,004.72 kg	63,088.86 kg
NO_x	4,228.11 kg	965.22 kg	3,262.89 kg	68,509.62 kg
Total:				
CO_2	2,230,273.23 kg	509,139.92 kg	1,721,133.31 kg	36,137,909.27 kg
SO_2	3,918.14 kg	913.42 kg	3,004.72 kg	63,088.86 kg
NO_x	4,228.11 kg	965.22 kg	3,262.89 kg	68,509.62 kg

APPENDIX C
Example of a FEMP Product Energy Efficiency Recommendation

Commercial Unitary Air Conditioner Recommendation		
Product Type[a] and Size	**Recommended**	**Best Available**
< 65 MBtu/h (3 phase)	**12.0 SEER or more[b]**	**14.5 SEER**
65 - 135 MBtu/h	**11.0 EER or more 11.4 IPLV or more**	**11.8 EER 13.0 IPLV**
> 135 - 240 MBtu/h	**10.8 EER or more 11.2 IPLV or more**	**11.5 EER 13.3 IPLV**

***[a]** Only air-cooled single package and split system units used in commercial buildings are covered. Water source units are not covered by ENERGY STAR®, but look for efficiency ratings that meet or exceed these levels for air source units.*
***[b]** Where operating conditions are often close to rated conditions or in regions where there are high demand costs, look for units with the highest EER ratings that also meet or exceed this SEER.*

***EER, or Energy Efficiency Ratio**, is the cooling capacity (in Btu/hour) of the unit divided by its electrical input (in watts) at the Air Conditioning and Refrigeration Institute's (ARI) standard peak rating condition of 95°F.*

***SEER (Seasonal Energy Efficiency Ratio)** and **IPLV (Integrated Part-Load Value)** are similar to EER but weigh performance at different (peak and off-peak) conditions during the cooling season.*